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September 15, 2006

National Renewable Energy Laboratory
Attn: NREL Technical Monitor, Harin Ullal, MS 3212
Golden, CO 80401

Re: D.1.2, Quarterly Status Report, Thin-Film Photovoltaics Partnership Program subcontract ZXL-6-44205-15, entitled, “High Productivity Annealing for Thin Film CIS PV”

Dear Dr. Ullal:

This letter constitutes the second quarterly status report of the abovementioned subcontract.

The purpose of this Thin-Film Photovoltaics Partnership Specialized Contributors project is to do specialized materials preparation research aimed at accelerating the commercialization of thin-film $CuInSe_2$ (CIS) PV modules by developing high-productivity layer-to-film annealing capable of eliminating processing bottlenecks associated with slow, batch-style annealing. The overall objective is to demonstrate that efficient CIS devices can be fabricated using High Productivity Annealing (HPA).

The work consists of three primary tasks. The first task involves the design and fabrication of suitable HPA equipment and the identification of processing parameters that yield efficient small-area CIGS cells. The second task involves the development of an HPA process yielding 10% CIS alloy devices. The third task involves the design and demonstration of high-through-put HPA processing that provides a 10 minute cycle time in a manner consistent with high-yield production processing.

During this quarter scoping experiments designed to delineate the major processing parameters utilized a modified Jipelec JetFirst 150 rapid thermal processing system (Fig. 1). The JetFirst system includes a cold wall reaction chamber, a quartz top-side window, and a 30 kW multi-zone halogen lamp source for rapid one-sided heating. The primary processing parameters in the JetFirst are temporal temperature profile (i.e. T(t)), total gas pressure, and gas composition; the secondary processing parameters include heating logistics (e.g. lamp spectrum, spatial uniformity, temporal stability, etc.), sample specifics (e.g. sample emissivity, thermal mass, etc.) and auxiliary component details (e.g. susceptor, if any).

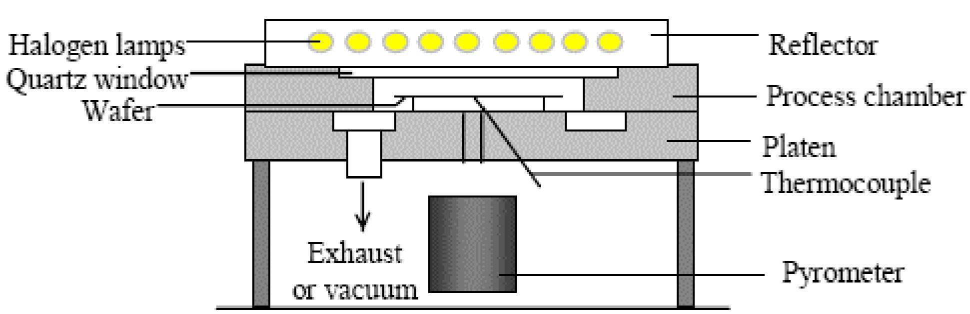

Figure 1: Basic lay-out of Jipelec JetFirst RTP system

HPA scoping experiments explored the basic functionality of the machine and the environment necessary to process samples of interest. A comparison between the anticipated spectral output of the JetFirst's array of quartz halogen lamps and the optical absorbance of various potential target materials is given in Figure 2. It is apparent that bare metal foil substrates and Mo-coated substrates have low absorbance in the wavelength range in which the halogen lamps are most intense. The opposite is true for the final CIGS films. The precursor layers are intermediate. As a result an opaque susceptor will be useful.

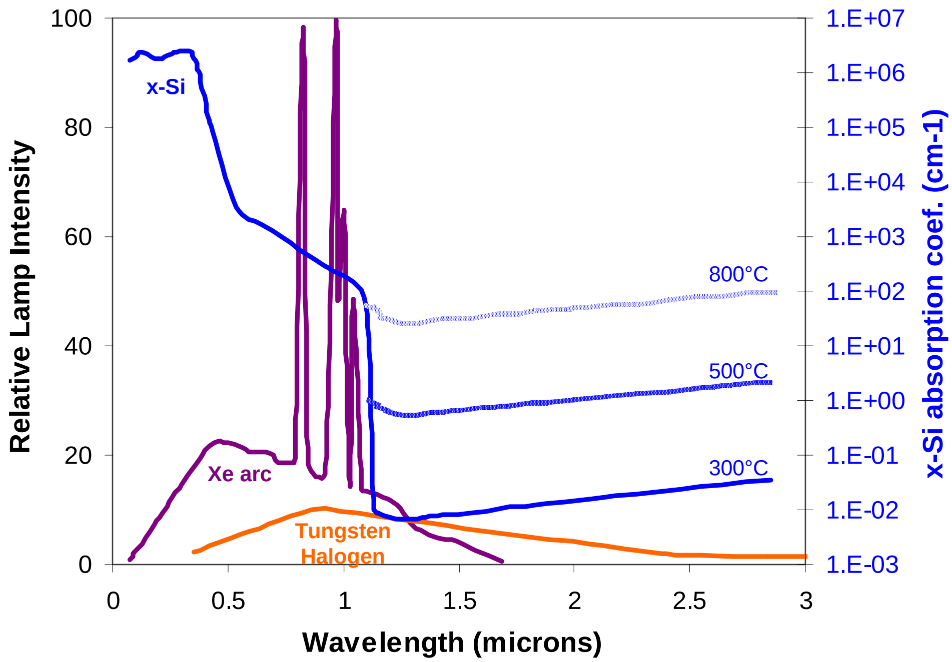

Figure 2a: Spectral output of halogen lamps of the type used in the JetFirst.

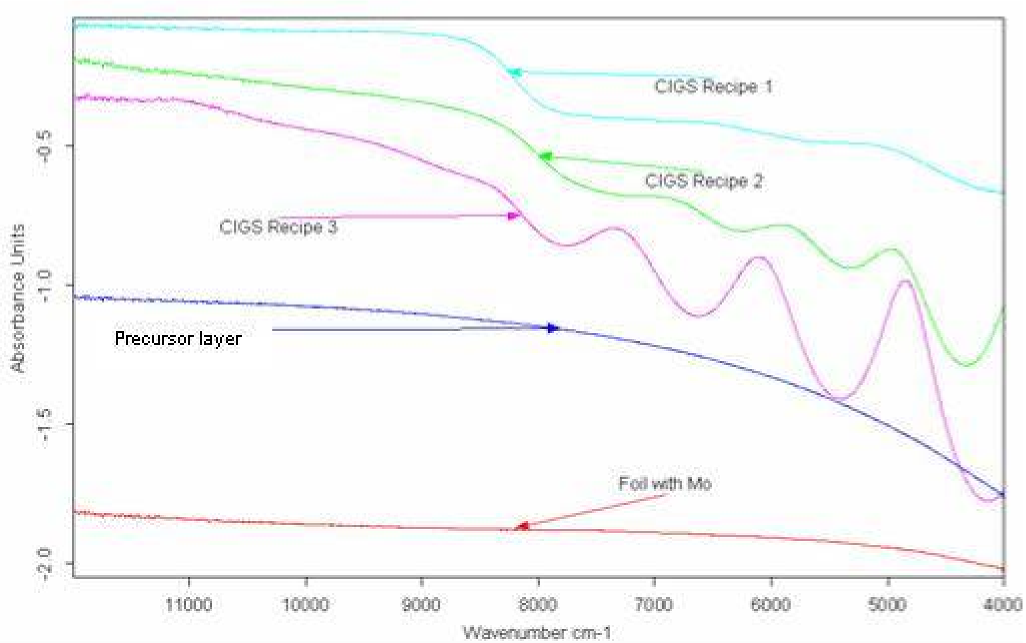

Figure 2b: Optical absorbance for various surfaces of interest

The JetFirst can accommodate 6 inch diameter round wafers, i.e. equivalent to ~11 cm square sample sizes. Low-mass graphite susceptors are being designed to accommodate a range of sample sizes and configurations, e.g. rigid and flexible substrates. Experiments with early-generation susceptors are underway now and will be reported on next quarter.

Work during the next quarter will continue to focus on Task 1.2, experimental evaluation of the primary impacts of key HPA processing parameters.

The overall status of this project was scheduled to be presented at the Solar Program Review meeting in November; but the open forum was canceled, and Nanosolar had not yet received guidance on when or where it is to present.

Sincerely,

Chris Eberspacher
Nanosolar Principal Investigator

cc: NREL Subcontract Administrator, Loretta Schmidt, MS 1735
NREL Publication Services, Judy Hulstrom, MS 1713